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NESTING SUCCESS OF YELLOW-BREASTED CHATS: EFFECTS OF NEST SITE AND TERRITORY VEGETATION STRUCTURE

MATTHEW S. RICKETTS[1] AND GARY RITCHISON[1, 2]

ABSTRACT.—The effects of habitat and vegetation characteristics on the reproductive success of Yellow-breasted Chats (*Icteria virens*) were examined in central Kentucky. During the 1998 breeding season, 49 nests were located and monitored and the characteristics of nest sites and territories determined. Habitats where nests were located were categorized as old field, linear, or clump, and nests were classified as early or late. Chat nests were located in areas with more foliage and lateral cover than unused sites. However, most nests (55%) were not successful, and variables that differed between nest sites and random locations did not appear to influence nesting success. A diverse and, in an evolutionary sense, novel community of predators may eliminate predictably safe nest sites for chats on our study area. Chats in territories with more foliage cover and less canopy cover were more likely to fledge young. Dense foliage may lower the chances of nest predation by increasing the number of potential nest sites in a territory and may also provide better foraging habitat. *Received 29 Feb. 2000, accepted 18 July 2000.*

When choosing a nest site, songbirds may select habitat patches (Martin and Roper 1988) that improve their chances of successfully fledging young. For example, large shrub patches may contain more potential nest sites for a visually searching predator to investigate (Martin and Roper 1988) and more effectively screen nests and the actions of parents than smaller patches (Holway 1991). Habitat features within patches may also influence nesting success. For example, successful Hermit Thrush (*Catharus guttatus*) nests were characterized by a greater density of white fir (*Abies concolor*) saplings and greater concealment than unsuccessful nests (Martin and Roper 1988), and successful Hooded Warbler (*Wilsonia citrina*) nests had more fern (primarily *Woodwardia areolata* and *Polystichum acrostichoides*) cover than unsuccessful nests (Kilgo et al. 1996). In contrast to these results, other investigators have failed to detect any relationship between the characteristics of either nest patches or nest sites and nesting success (Filliater et al. 1994, Howlett and Stutchbury 1996, Braden 1999). Clearly, additional data are needed concerning the possible relationship between nest-site selection and nesting success.

Habitat features within breeding territories independent of nest sites may also affect reproductive success. For example, nesting success among Northern Cardinals (*Cardinalis cardinalis*) in Texas was positively correlated with the presence of patchy understory foliage and arthropod biomass (Conner et al. 1986). Similarly, California Gnatcatchers (*Polioptila californica*) nested earlier and produced more fledglings when territories included more grass and forb cover, perennial structure, and horizontal perennial homogeneity, with less vertical perennial homogeneity and perennial diversity (Braden et al. 1997).

Yellow-breasted Chats (*Icteria virens*) breed in early successional habitats with an abundance of weedy cover and scattered trees (Palmer-Ball 1996). Dense thickets of blackberry (*Rubus* sp.), multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*) are commonly used for nesting (Dennis 1958, Thompson and Nolan 1973). Although chats typically nest in areas with dense thickets, little is known about the specific vegetational features at nest sites and within territories that might influence their reproductive success. Burhans and Thompson (1999) reported that chats experienced less predation and higher rates of parasitism in large (>5.5 m diameter) nest patches; however, few specific nest site characteristics were measured. The objective of our study was to examine nest site selection by Yellow-breasted Chats in central Kentucky at the territory, patch, and nest site levels and, specifically, to quantify the vegetation structure at chat nest sites and within territories and to determine which, if any, habitat features were correlated with reproductive success.

[1] Dept. of Biological Sciences, Eastern Kentucky Univ., Richmond, KY 40475.

[2] Corresponding author; E-mail gritchis@acs.eku.edu

METHODS AND MATERIALS

We studied chats from April–July 1998 at the Central Kentucky Wildlife Management Area, 17 km southeast of Richmond, Madison County, Kentucky. The area (621 ha) consists of a mosaic of deciduous woodlots, old fields, and fencerows. Old fields were dominated by various herbaceous species plus thickets of smooth sumac (*Rhus glabra*) and blackberry (*Rubus allegheniensis*); fencerows included eastern redcedars (*Juniperus virginiana*) and black locusts (*Robinia pseudoacacia*) plus thickets of multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), smooth sumac, and blackberry.

Beginning in late April, we captured chats in mist nets and banded them with a numbered USFWS leg band and a unique combination of colored plastic bands. We delineated territorial boundaries by monitoring the movements of males and noting the location of singing males and aggressive encounters.

Chat nests were located by following females carrying nest material and searching areas where we observed chats. Once located, nests were checked every three to four days until young fledged or the nest was lost to predation. Nests (and territories) from which at least one young fledged were classified as successful, while those from which no young fledged were classified as unsuccessful. To evaluate the potential influence of time on nesting success, nests were also classified, based on the date of initiation, as either early (before 15 June) or late (after 15 June). We evaluated chat reproductive success using both simple nesting success (number of successful nests/total nests) and the Mayfield method (Mayfield 1975). Survival probabilities between early and late nests and among patch categories (below) were compared using CONTRAST (Sauer and Williams 1989, Hines and Sauer 1989).

Nest sites were assigned to one of three habitat or patch categories: old field, linear, or clump. Old fields were larger than 1 ha and included various grasses and forbs plus scattered small trees and shrubs. Linear habitats were narrow strips (<10 m wide and >0.5 ha) along fencerows, roadsides, and the edges of woodlots. Clumps were defined as areas smaller than 0.5 ha consisting of small trees and shrubs (<10 m tall) and surrounded by old field habitat.

Vegetation structure at chat nests and within territories was quantified using 0.04 ha circular plots (James and Shugart 1970). Nest sites were sampled 2–30 days after either fledging or nest failure to minimize disturbance. Nest site plots were centered at chat nests. To sample vegetation within territories, the approximate center of each territory was located and three circular plots were then located at random distances from the center at compass bearings of 90°, 210°, and 330° (Conner et al. 1986). Data from these plots were averaged. Variables measured in each plot included percent foliage cover at vertical intervals of below 1 m, 1–2 m, and 2–3 m, number of trees less than and greater than 8 cm diameter at breast height (dbh), percent canopy cover, percent ground cover, foliage height, percent lateral cover at vertical intervals of less than 1 m, 1–2 m, and 2–3 m, and percent cover of dominant understory plants such as grasses, forbs, shrubs, and bare ground (see Larison et al. 1998 for methods of estimation). In addition, nest height, substrate, and concealment were measured in nest-site plots. Percent concealment was calculated by estimating how much of a nest was obscured by foliage when viewed at nest height level from 1 m. Each nest was viewed from the four cardinal directions and an average percent concealment determined.

We used stepwise logistic regression to determine which habitat variables best distinguished successful from unsuccessful nests and territories. Successful and unsuccessful nests and territories were first compared using univariate Wilcoxon 2-sample tests (Nadeau et al. 1995, Rabe et al. 1998). Variables with $P < 0.15$ were included in the initial regression model (Nadeau et al. 1995). Subsequently, variables were included (score χ^2 statistic) or removed (Wald's χ^2 statistic) from logistic regression models using a criterion of $P < 0.25$. Kendall correlation coefficients were calculated to ensure that variables were not highly correlated ($\tau_b > 0.40$; Nadeau et al. 1995). Wald's χ^2 statistics were used to assess the contribution of individual variables to the model. Overall model significance was based on log-likelihood χ^2 statistics, classification accuracy (based on a logistic cutpoint of 0.5 to classify nests/territories as successful or unsuccessful), and the Hosmer-Lemeshow lack-of-fit test (Rabe et al. 1998). Positive parameter coefficients in the logistic regression equations indicated that an increase in the value of a variable increased the probability of a nest-site/territory being successful. Conversely, a negative coefficient indicated that as the value of the variable increased, the probability of the nest site/territory being successful decreased.

We also compared nest site and territory vegetation for 19 territories. When a pair made more than one nesting attempt, data were pooled. Values were compared using Wilcoxon 2-sample tests. A stepwise logistic regression model comparing nest site and territory vegetation data was then built using procedures described previously.

Using univariate Wilcoxon 2-sample tests, we also compared the characteristics of early and late nests. Nesting attempts that spanned early and late nesting periods ($n = 10$) and early nests not sampled until the late period ($n = 7$) were deleted to permit better comparison of vegetation around early and late nests. Characteristics of successful and unsuccessful nests for both early and late nests (i.e., successful vs unsuccessful early nests and successful vs unsuccessful late nests) were compared using Wilcoxon 2-sample tests. All analyses were performed using SAS software (ver. 6.09 for VAX Alphaserver; SAS Institute 1989). All values are reported as mean ± one standard error.

RESULTS

Chat nests ($n = 57$) were located in 13 plant species, with blackberry the most frequently

TABLE 1. Results of stepwise logistic regression analysis comparing Yellow-breasted Chat nest-site and territory vegetation characteristics.

Variable	Coefficient	SE[a]	Wald χ^2	P
Intercept	−21.514	9.214	5.452	0.019
% foliage cover < 1 m	0.232	0.102	5.189	0.023
% foliage cover 1–2 m	0.120	0.086	1.938	>0.05

[a] Standard error.

used substrate (n = 26). Among the other species used by nesting chats were multiflora rose (n = 7), Japanese honeysuckle (n = 5), roughleaf dogwood (*Cornus drummondi*; n = 4), coralberry (*Symphoricarpos orbiculatus*; n = 3), black locust (n = 3), and eastern redcedar (n = 3). Mean nest height was 78.7 ± 4.1 cm, while mean concealment was 73.6 ± 3.1%. Nests abandoned (n = 3), destroyed by storms (n = 4), or with incomplete data (n = 1) were not used for subsequent analyses. Of the remaining 49 nests, 22 (45%) were successful. The daily survival rate (Mayfield 1975) was 0.96 ± 0.007, and rates did not vary among patch types (χ^2 = 0.35, 2 df, $P > 0.05$). Most nests lost to predation were found empty and undisturbed. No chat nest was parasitized by Brown-headed Cowbirds (*Molothrus ater*).

Foliage cover below 2 m was greater at nest sites than in other areas of chat territories and nest sites had more lateral cover below 1 m (Wilcoxon tests: $P < 0.01$). The final logistic regression model predicting the probability that a site would be used as a nest site by chats included two variables: foliage cover below 1 m and from 1–2 m (Log likelihood χ^2 = 38.4, $P < 0.001$; Table 1). The model correctly classified 88.9% of the data used to build the model and provided good fit to the data (Hosmer-Lemeshow lack-of-fit; χ^2 = 1.03, 7 df, P = 0.99).

Univariate Wilcoxon 2-sample tests revealed significant ($P < 0.05$) differences between successful and unsuccessful nests for two of 17 variables. Successful nests had higher forb cover and lower shrub cover than unsuccessful nests (Table 2). Three other variables (nest height, percent foliage cover at 2–3 m, and number of trees > 8 cm dbh) met our criterion of $P < 0.15$ (Table 2) and were used in the stepwise logistic regression model-building procedure. Only one nest-site char-

TABLE 2. Results of univariate comparisons (Wilcoxon 2-sample tests) between successful and unsuccessful chat nests.

	Successful (n = 22)		Unsuccessful (n = 27)		
Variable	Mean	SE	Mean	SE	P
Nest height (cm)	82.9	4.9	75.2	6.4	0.07
% nest concealment	75.4	4.5	72.0	4.4	>0.05
# trees < 8 cm dbh	61.8	17.0	53.9	6.4	>0.05
# trees > 8 cm dbh	4.3	1.3	7.8	1.7	>0.05
Foliage height (m)	2.2	0.3	2.4	0.3	>0.05
% foliage cover < 1 m	90.5	2.2	89.9	1.7	>0.05
% foliage cover 1–2 m	37.0	3.6	39.9	3.4	>0.05
% foliage cover 2–3 m	7.7	2.4	13.1	2.9	0.10
% lateral cover < 1 m	99.1	0.3	95.4	2.1	>0.05
% lateral cover 1–2 m	63.6	5.5	59.2	5.0	>0.05
% lateral cover 2–3 m	38.6	6.5	43.1	5.1	>0.05
% canopy cover	18.2	4.6	28.6	4.8	>0.05
% ground cover	97.5	1.7	97.0	1.4	>0.05
% grass cover	11.4	3.1	17.8	4.2	>0.05
% forb cover	57.5	7.8	31.1	6.8	0.01
% shrub cover	30.1	6.5	51.2	7.0	0.04
% bare ground	0.1	0.1	0.2	0.2	>0.05

TABLE 3. Results of stepwise logistic regression analyses comparing vegetation characteristics of successful and unsuccessful Yellow-breasted Chat nests and territories.

Variable	Coefficient	SE	Wald χ^2	P
Nest model:				
Intercept	−0.986	0.492	4.019	0.045
% forb cover	0.019	0.008	5.174	0.023
Territory model:				
Intercept	−6.027	4.985	1.461	>0.05
% foliage cover < 1 m	0.154	0.093	2.736	>0.05
% canopy cover	−0.074	0.059	1.589	>0.05

acteristic, percent forb cover ($P < 0.25$), was included in the final logistic regression model comparing successful and failed nests (Log likelihood $\chi^2 = 5.61$, $P = 0.018$; Table 3). The model correctly classified 66% of the data used to build the model (Hosmer-Lemeshow lack-of-fit test; $\chi^2 = 5.74$, 6 df, $P = 0.45$).

We sampled vegetation in 14 successful and 5 unsuccessful chat territories. Successful territories had greater ($z = 2.24$, $P = 0.02$) foliage cover below 1 m than unsuccessful territories. Four other variables (foliage height, percent foliage cover at 2–3 m, canopy cover, and percent bare ground) met our criterion of $P < 0.15$ and were used in the initial logistic regression model. The final model predicting the probability that young would fledge in a chat territory included two variables, percent foliage cover below 1 m and canopy cover (Log likelihood $\chi^2 = 8.35$, $P = 0.015$; Table 3). The canopy cover coefficient was negative, with successful territories having less canopy cover ($\bar{x} = 16.0 \pm 4.1\%$) than unsuccessful ($\bar{x} = 31.6 \pm 5.4\%$) territories. The model correctly classified 67% of the data used to build the model (Hosmer-Lemeshow lack-of-fit test; $\chi^2 = 5.15$, 7 df, $P = 0.64$).

The daily survival rates of early (0.96 ± 0.009) and late (0.97 ± 0.011) nests did not differ ($\chi^2 = 0.47$, 1 df, $P > 0.05$). However, differences between early (1.1 ± 0.3) and late (1.8 ± 0.4) nests in the mean number of fledglings approached significance ($z = 1.91$, $P = 0.06$). Several habitat variables of early and late nests differed (Fig. 1). Early nests had less lateral cover below 1 m but greater foliage cover and lateral cover between 2–3 m than late nests (Fig. 1). Small (<8 cm dbh) trees were more numerous around early nests ($z = 2.82$, $P = 0.005$) and foliage height ($z = 1.99$,

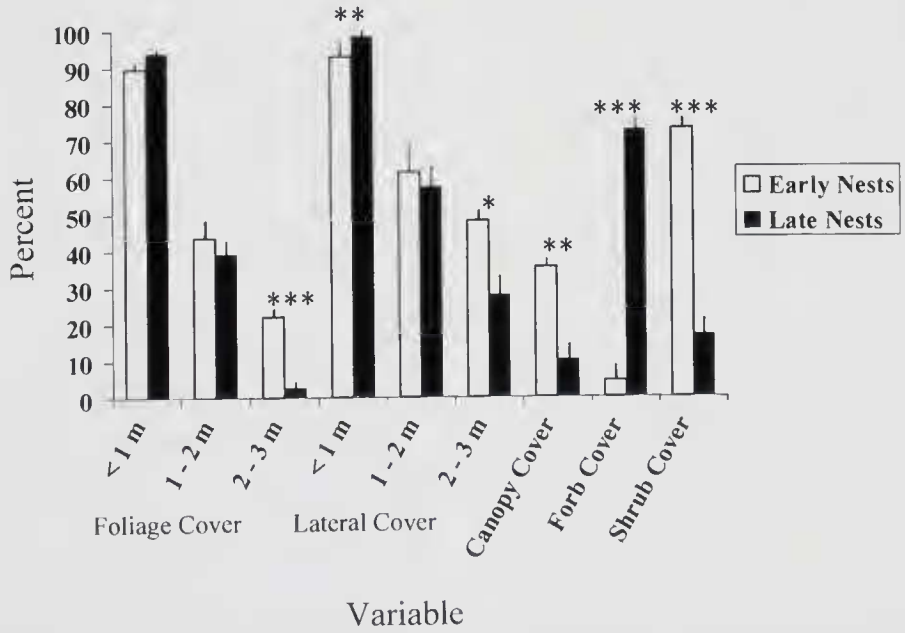

FIG. 1. Comparison of the characteristics of early (before 15 June) and late (after 15 June) Yellow-breasted Chat nests (* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$).

$P = 0.046$), canopy cover, and shrub cover were also greater at early nests. Late nests had more forb cover than early nests (Fig. 1).

DISCUSSION

Nearly half of the Yellow-breasted Chat nests in our study were located in blackberry, as were many chat nests in Missouri (Burhans and Thompson 1999). Blackberry commonly grows in dense thickets that, in addition to providing concealment, could potentially provide additional protection from predators via the presence of numerous thorns. However, Ricketts (1999) found no differences in the daily survival rates of chat nests located in blackberry versus other plant species. While dense, thorny thickets of blackberry could potentially impede some predators (e.g., large mammalian predators such as raccoons, *Procyon lotor*), other predators, including snakes and small mammals are likely not deterred by such vegetation.

The nests of Yellow-breasted Chats in our study were located in areas with more foliage (and lateral) cover than unused sites. Despite such placement, most chat nests were not successful; we found no differences between successful and unsuccessful chat nests in foliage and lateral cover or percent concealment. Similarly, Braden (1999) found that nest placement by California Gnatcatchers was not random, with nests placed in locations with more cover and taller vegetation than random locations. However, variables that differed between nest sites and random locations did not influence nesting success. Other investigators have reported similar results (Conner et al. 1986, Holway 1991, Howlett and Stutchbury 1996, Wilson and Cooper 1998).

One possible explanation for the absence of differences in the characteristics of successful and unsuccessful nests in chats and other species is the presence of a diverse community of predators. Among the many potential nest predators on our study site in central Kentucky were coyotes (*Canis latrans*), raccoons, feral cats (*Felis domesticus*), eastern chipmunks (*Tamias striatus*), long-tailed weasels (*Mustela frenata*), Blue Jays (*Cyanocitta cristata*), American Crows (*Corvus brachyrhynchos*), black rat snakes (*Elaphe obsoleta*), and blue racers (*Coluber constrictor*). Filliater and coworkers (1994) found no relationships between the characteristics of nest sites and nesting success in a population of Northern Cardinals and suggested that environments with a variety of predators, each using a different search strategy, may eliminate predictably safe nest sites. Passerines in environments where nest predation is unpredictable (Schmidt and Whelan 1999) and where most or all nest locations are subject to similar predation risk may respond by following simple behavioral rules for nest placement (Filliater et al. 1994). For chats, these rules would include placing nests low ($\leq$1 m above the ground), in locations with little or no canopy cover, and dense foliage cover that provides some concealment. These rules may be of only limited benefit in predator-rich communities (Filliater et al. 1994), but even limited benefits may be of value (Schmidt and Whelan 1999).

Another possible explanation for our results is that there has been strong selection on nest site choice by Yellow-breasted Chats in the eastern United States. However, this selection occurred in an environment that no longer exists in most areas. Chats occupy early successional habitats and, throughout much of eastern North America prior to the arrival of Europeans, such habitats were less abundant and may have been limited to natural forest openings caused by windstorms or fire (Palmer-Ball 1996). Man-made openings created by forest management practices (e.g., clearcutting) are readily used by chats (Thompson et al. 1992). In natural openings surrounded by extensive tracts of deciduous forest, the predator community differed, and, where larger tracts of forest remain, still differs (Suarez et al. 1997) from that found in many areas now occupied by chats in the eastern United States, including our study site. Some predators present on our study site were not present in the past; others were absent or uncommon (Wilcove 1988; Durner and Gates 1993). It is likely, therefore, that a primary breeding habitat used by chats in the past (natural forest openings) supported a less diverse predator community. If so, chats on our study area might be selecting nest sites based on behavioral rules developed in response to a predator community that no longer exists.

Although variables that differed between chat nest sites and random locations (foliage

cover below 2 m) did not influence nesting success in our study, successful nests had more forb cover than unsuccessful nests. In addition, at the territory scale, chats in our study were more likely to fledge young in territories with more foliage cover below 1 m (including forb cover) and less canopy cover. Chats glean insects from low foliage in dense thickets and occasionally forage on the ground (Dunn and Garrett 1997). Thus, one explanation for our results is that increased foliage cover might provide better foraging substrate and more arthropods for chats. Similarly, Conner and coworkers (1986) reported that Northern Cardinals had greater fledging success in territories with more understory foliage (and arthropod biomass). Greater forb and foliage cover may also increase the number of potential nest sites in a territory, and increase the number of potential sites for predators to examine, lowering the chance of nest predation (Martin and Roper 1988).

Although we found no differences in daily survival rates between early and late nests, the mean number of young fledged per nest increased later in the breeding season. Other investigators have also reported increased nesting success later in the breeding season (Longcore and Jones 1969, Thompson and Nolan 1973, Best 1978, Filliater et al. 1994). One possible explanation for such seasonal differences in early successional habitats is reduced predation pressure later in the season, particularly by snakes. Roseberry and Klimstra (1970:264) noted that snakes were frequently observed in May but became "progressively more scarce in June and July" in southern Illinois. Similarly, Nolan (1978) attributed a July rise in the reproductive success of Prairie Warblers (*Dendroica discolor*) and other birds in a study area in Indiana to decreased snake activity.

Daily survival rates did not vary among habitat or patch types in our study. Burhans and Thompson (1999) found that chats nesting in larger patches experienced less predation; however, they defined large and small patches as being either more or less than 5.5 m diameter, respectively (the smallest patch was 0.3 m diameter). Thus, we may not have noted differences among patch types because most or all of our patches were large, based on Burhans and Thompson's (1999) definition. Patch size and shape may influence nest predation rates via differences in the number of potential nest sites (Martin and Roper 1988) and the screening of nests and parental activity (Holway 1991); detecting such differences may require examination of smaller patches than those observed in our study.

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